Appendix D
Shadow-flicker Report

Rose Creek Wind, LLC
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SHADOW FLICKER ASSESSMENT
ROSE CREEK WIND PROJECT, MINNESOTA

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Revision History

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1.0 EXECUTIVE SUMMARY

ConEdison Development (CED), a New York renewable energy development and operations company doing business as Rose Creek Wind, LLC is planning to re-power an existing wind energy facility in Mower County, Minnesota. The re-powered wind energy facility will be called the Rose Creek Wind Project (the Project).

The proposed re-power Project will involve decommissioning the 11 Rose Wind turbines and constructing 6 to 7 new turbines with greater power outputs to deliver up to 17.4 MW of electricity to the power purchaser. There are two scenarios for the proposed Project:

- Scenario 1 consists of five GE 2.82/127 turbines at a hub height of 89 m and one GE 2.3/116 turbine at a hub height of 80 m;
- Scenario 2 consists of four Siemens Gamesa G97 2.0 MW (G97-2.0) turbines at a hub height of 100 m, two GE 2.82/127 turbines at a hub height of 89 m, and one GE 2.3/116 turbine at a hub height of 80 m.

This assessment uses industry-standard software and Project-specific data to predict the shadow flicker generated by the Project at provided receptor locations within or near the Project area. The analysis assessed potential shadow flicker generated by each scenario and the effects on the surrounding area and 42 identified receptors. The receptors include 41 residences of which 40 have confirmed occupation and one that is assumed to be occupied, and one additional occupied non-residential structure. Nine receptors are on properties participating in the Project.

The shadow flicker analysis was conducted assuming 100 percent sunshine and using a probability-based model that considers the probability of sunshine due to cloud cover for each month and the dispersion of light when the sun is below 3 degrees on the far horizon. The model is inherently conservative, as it assumes that turbines are always spinning and always perpendicular to the path of the sunlight to each receptor. While there are no regulations prescribing shadow flicker limits, CED set a Project goal of a maximum of 30 hours per year for any receptor, which has become part of a shadow flicker mitigation plan permit condition applied in practice by the Minnesota Public Utilities Commission (MNPUC).

The 100 percent sunshine model shows that 6 receptors may experience more than 30 hours per year of shadow flicker for Scenario 1 and Scenario 2. The maximum amount of shadow flicker for the 100 percent model is 65 hours per year for Scenario 1 and 99 hours per year for Scenario 2. When cloud cover is considered in the probability-based model, no receptors experience more than 30 hours of shadow flicker per year. The maximum shadow flicker for the probability-based models is 13 hours per year for Scenario 1 and 22 hours per year for scenario 2, both well below the 30 hour per year standard.

Table 1 provides a summary for shadow flicker analysis for each scenario. Based on the results of the probability-based model, no receptors will experience more than 30 hours per year of shadow flicker from the Project.

Table 1 Shadow flicker summary results

	Scenario 1		Scenario 2	
	Maximum (100% Sunshine)	**Probability Based (Cloud Cover)**	**Maximum (100% Sunshine)**	**Probability Based (Cloud Cover)**
Receptors w/ shadow flicker	16	16	20	20
> 30 hr/year	5	0	4	0
> 50 hr/year	1	0	2	0
> 100 hr/year	0	0	0	0
Maximum hr/year	65	13	99	22
Maximum 1-day max (min)	57	18	107	30
Maximum days/year	112	109	114	110

2.0 INTRODUCTION

CED, doing business as Rose Wind Holdings, LLC, purchased the 11 Rose Wind turbines in 2015. CED will decommission the 11 existing Rose Wind turbines, and Rose Creek Wind, LLC will build, own and operate 6 to 7 new turbines with greater power outputs to continue to produce up to 17.4 MW of electricity. There are two scenarios for the proposed Project, which are detailed in Section 4.0.

This assessment uses industry-standard software and Project-specific data to predict the shadow flicker levels generated by the Project at provided receptor locations within or near the Project area. While there are no regulations prescribing shadow flicker limits, CED set a Project goal of a maximum of 30 hours per year for any receptor, which has become part of a shadow flicker mitigation plan condition applied in practice by the Minnesota Public Utilities Commission (MNPUC). The analysis assessed potential shadow flicker generated by each scenario and the effects on the surrounding area and 42 identified receptors and determined if the Project is in compliance with the standard.

KiloNewton performed the analysis using UL's Openwind software, an industry-standard wind analysis program. Openwind incorporates a shadow flicker model with various options to assess a project based on terrain, climatology, and other factors. KiloNewton has supplemented the Openwind model with internal procedures to provide accurate and detailed results based on the needs and variations for specific projects.

3.0 SITE SUMMARY

The proposed Project is in a rural area with the small town of Adams to the north and multiple surrounding wind farms. The shadow flicker analysis evaluated impacts from the Project on 42 identified receptors in the general area of the Project. While multiple other wind farms exist within 10 km of the Project but are not included in this analysis since shadow flicker is independent for each turbine and is not a cumulative effect.

Figure 1 shows all the proposed Project turbine locations and the receptor locations used in this analysis, including the closest turbines from the nearby wind farms. The coordinates for each scenario are identical with the exception that Scenario 2 includes T1. The 42 identified receptors include 41 occupied receptors and one, R-253, that is assumed to be occupied. Table 2 provides the details for each turbine for each scenario. Table 3 provides details for each receptor.

Scenario 1 consists of five GE 2.82/127 turbines with a rotor diameter of 127 m and hub heights of 89 m, and one GE 2.3/116 turbine with a rotor diameter of 116 m and a hub height of 80 m. Figure 2 shows the layout for Scenario 1 in relation to the receptors analyzed in this analysis.

Scenario 2 consists of four Siemens Gamesa G97 2.0 MW (G97-2.0) turbines with a rotor diameter of 97 m and a hub height of 100 m, two GE 2.82/127 turbines at a hub height of 89 m, and one GE 2.3/116 turbine at a hub height of 80 m. Figure 3 shows the layout for Scenario 2 in relation to the receptors analyzed in this analysis.

Table 2 Proposed layouts

Turbine ID	UTM 15N WGS84		Base Elevation (m)	Scenario 1	Scenario 2
	Northing (m)	Easting (m)			
T1	4,819,347	523,210	398		G97-2.0
T2	4,821,813	524,725	401	GE 2.82-127	G97-2.0
T3	4,820,872	524,498	400	GE 2.82-127	GE 2.82-127
T4	4,818,941	521,488	386	GE 2.3-116	GE 2.3-116
T5	4,819,170	522,165	390	GE 2.82-127	G97-2.0
T6	4,817,659	524,492	398	GE 2.82-127	G97-2.0
T7	4,817,046	524,927	400	GE 2.82-127	GE 2.82-127

Table 3 Modeled receptors

Receptor ID	UTM 15N WGS84 Northing (m)	UTM 15N WGS84 Easting (m)	Structure Type	Status	Occupation Status	Elevation (m)
R-2	4822987	520986	Residence	Non-participant	Occupied	392
R-3	4822896	521063	Residence	Non-participant	Occupied	394
R-4	4822870	521418	Residence	Non-participant	Occupied	401
R-5	4822796	521443	Residence	Non-participant	Occupied	400
R-7	4822940	522732	Residence	Non-participant	Occupied	395
R-8	4822670	523132	Residence	Participant	Occupied	394
R-9	4822795	523986	Residence	Participant	Occupied	402
R-10	4822762	524892	Residence	Participant	Occupied	404
R-11	4822687	524894	Residence	Participant	Occupied	405
R-12	4822801	525213	Residence	Non-participant	Occupied	409
R-13	4822805	526143	Residence	Non-participant	Occupied	413
R-229	4819583	519926	Residence	Non-participant	Occupied	380
R-230	4819646	520583	Residence	Non-participant	Occupied	389
R-231	4819020	520373	Other	Non-participant	Occupied	387
R-232	4818020	520377	Residence	Non-participant	Occupied	386
R-235	4821817	521854	Residence	Non-participant	Occupied	401
R-236	4821694	521958	Residence	Non-participant	Occupied	398
R-237	4821101	521959	Residence	Non-participant	Occupied	393
R-238	4819632	522212	Residence	Participant	Occupied	394
R-239	4818624	521879	Residence	Participant	Occupied	391
R-240	4817677	522003	Residence	Non-participant	Occupied	387
R-245	4819579	521349	Residence	Non-participant	Occupied	394
R-246	4822401	523571	Residence	Non-participant	Occupied	393
R-247	4821536	523573	Residence	Non-participant	Occupied	396
R-248	4820793	523636	Residence	Participant	Occupied	400
R-249	4819643	523422	Residence	Non-participant	Occupied	404
R-250	4818959	523575	Residence	Non-participant	Occupied	401
R-252	4817878	523589	Residence	Non-participant	Occupied	397
R-253	4816417	523991	Residence	Non-participant	Presumed Occupied	397
R-254	4816430	524029	Residence	Non-participant	Occupied	396
R-255	4816123	524882	Residence	Non-participant	Occupied	399
R-256	4816102	524804	Residence	Non-participant	Occupied	400
R-257	4816560	524808	Residence	Non-participant	Occupied	401
R-258	4819561	522916	Residence	Participant	Occupied	399
R-259	4818050	524099	Residence	Non-participant	Occupied	403
R-260	4817834	525110	Residence	Non-participant	Occupied	398
R-261	4818774	525100	Residence	Non-participant	Occupied	399
R-262	4819661	525279	Residence	Non-participant	Occupied	403
R-263	4819963	524892	Residence	Participant	Occupied	401
R-264	4821152	525302	Residence	Non-participant	Occupied	405
R-311	4816276	525524	Residence	Non-participant	Occupied	401
R-453	4823150	525336	Residence	Non-participant	Occupied	396

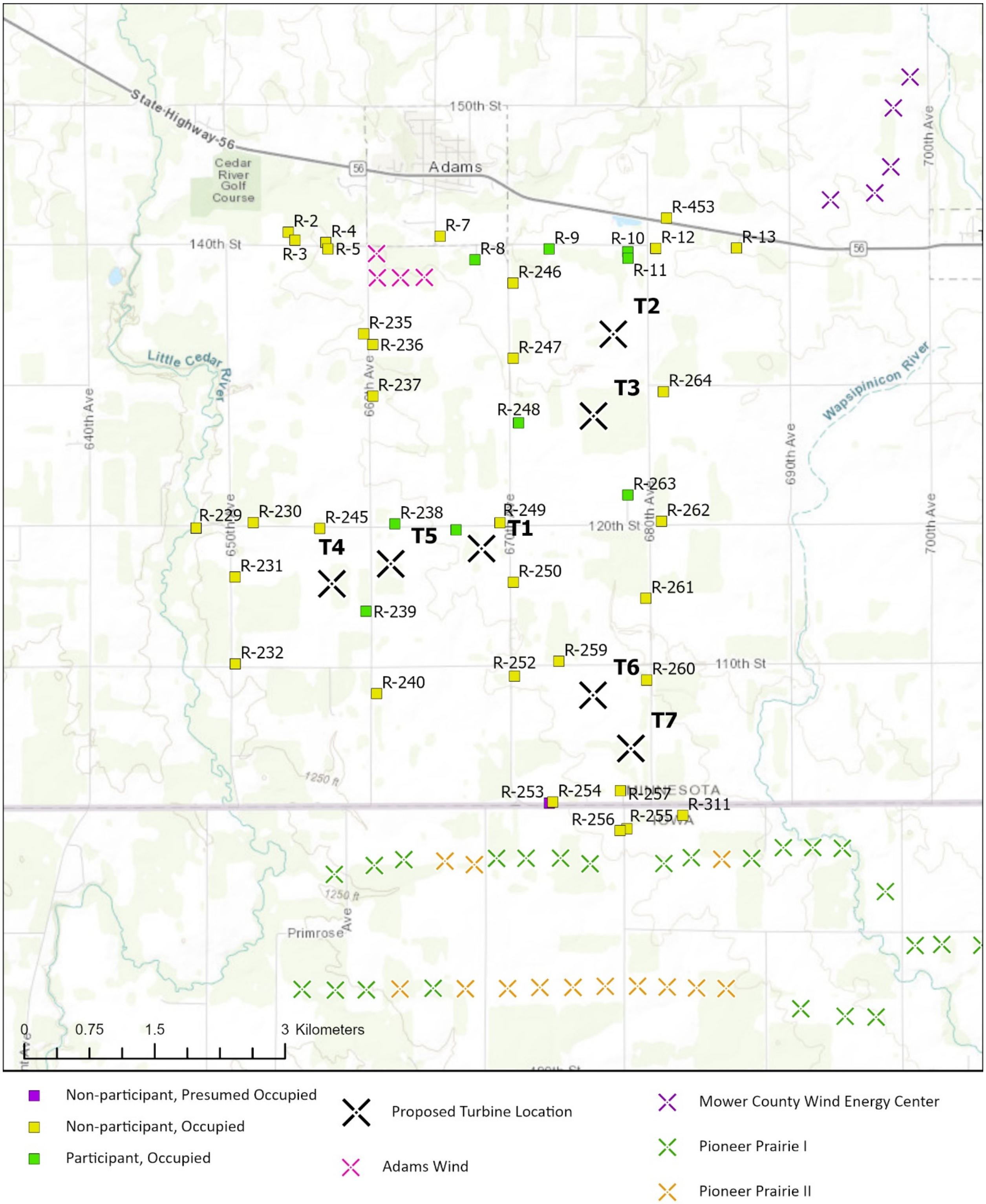

Figure 1 Proposed Project turbines, nearby receptors, and adjacent existing turbines

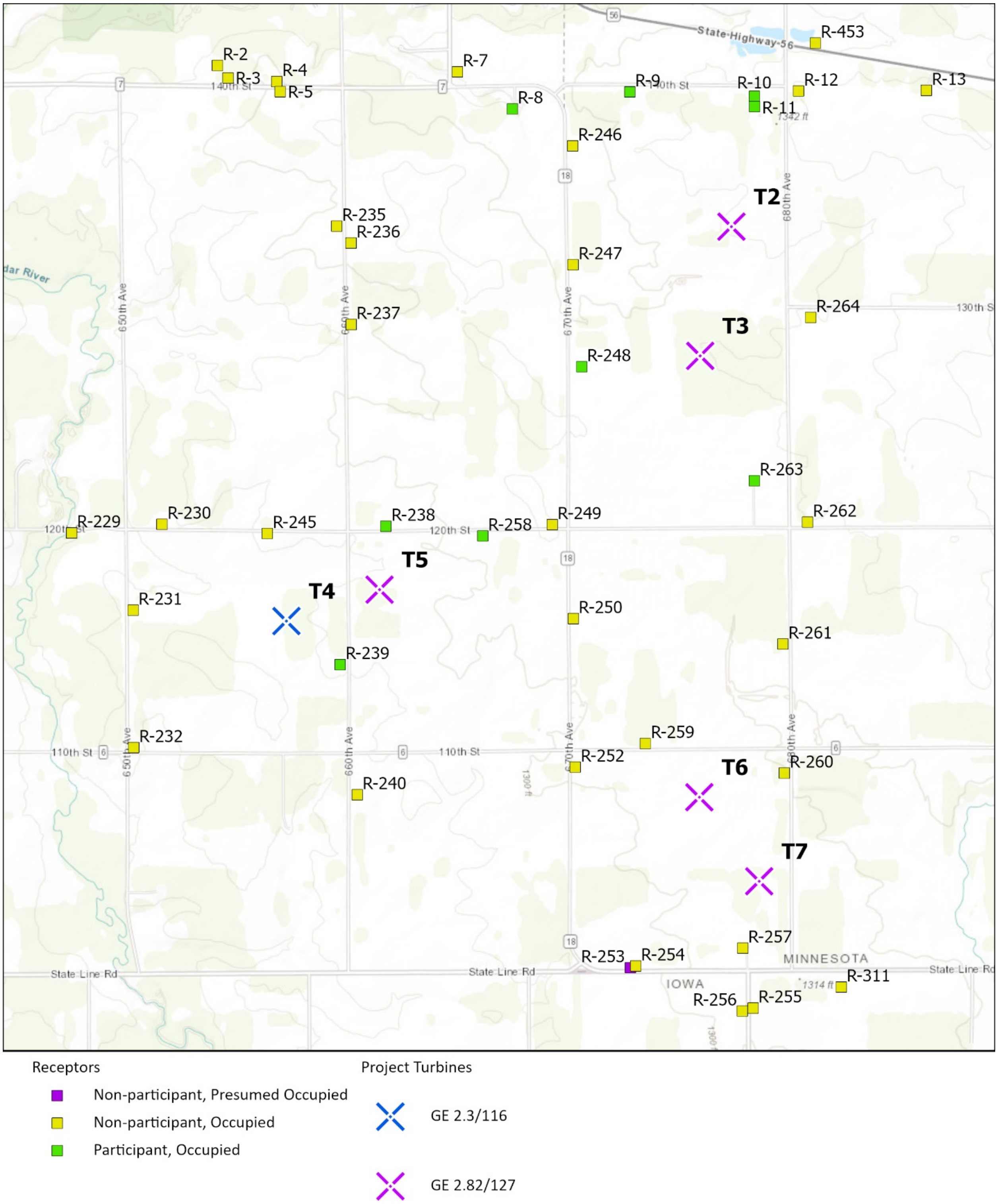

Figure 2 Scenario 1 proposed layout and nearby receptors

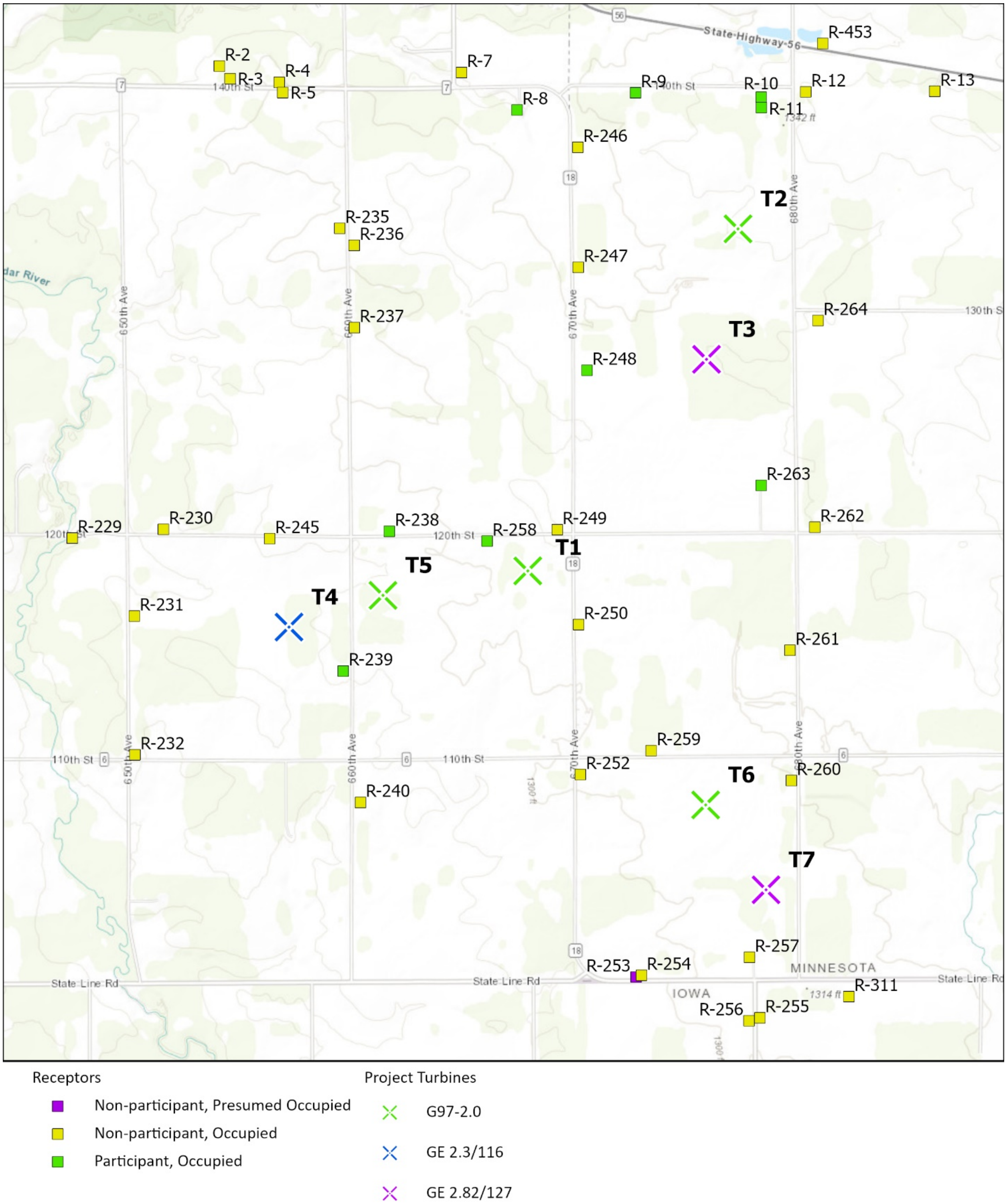

Figure 3 Scenario 2 proposed layout and nearby receptors

3.1 Turbine Specifications

Full turbine specifications were provided for the Project with the exception of the G97-2.0. Specifications or the GE turbines include general specifications and sound profiles.

The GE 2.82/127 is a three-bladed upwind turbine with a rated power of 2.82 MW, a rotor diameter of 127 m, a hub height of 89 m, a cut-in wind speed of 3 m/s, and a cut-out wind speed of 30 m/s. The GE 2.82/127 is an International Electrotechnical Commission (IEC) Class S turbine.

The GE 2.3/116 is a three-bladed upwind turbine with a rated power of 2.3 MW, a rotor diameter of 116 m, a hub height of 80 m, a cut-in wind speed of 3 m/s, and a cut-out wind speed of 22 m/s. The GE 2.3/116 is an International Electrotechnical Commission (IEC) Class S turbine.

For the G97-2.0, only the sound profile and hub height were provided. All other specifications were taken from published manufacturer data. The G97-2.0 is a three-bladed upwind turbine with a rated power of 2.0 MW, a rotor diameter of 97 m, a hub height of 100 m, a cut-in wind speed of 3 m/s, and a cut-out wind speed of 25 m/s. The G97-2.0 turbine is International Electrotechnical Commission (IEC) Class III/S turbine [1].

The model inputs for each turbine include hub height, rotor diameter, and cut-in and cut-out wind speeds. Since this analysis assumes the turbines are always spinning, power and thrust curves and other turbine-specific operational data are not necessary for the model.

3.2 Terrain and Vegetation

The Project area is primarily agricultural with the small town of Adams, MN to the north. The terrain is mostly farmland with scattered groupings of trees typically near buildings and residences and the Little Cedar River to the west of the Project area.

4.0 SHADOW FLICKER ANALYSIS

Shadow flicker is described as the shadow effect caused by rotating wind turbine blades. Since the blades rotate relatively quickly, when the sun is in positions to cause shadows that extend to specified receptors, the effect is similar to a slow strobe light with alternating, or flickering, patterns of light and dark. Due to the setbacks of turbines from residences and other buildings, shadow flicker typically occurs during the morning and evening hours when the angle of the sun relative to a turbine casts long shadows on the ground. When experienced from inside a structure with windows, the effect can be perceived in different ways by different people, ranging from being an annoyance to potentially adversely affecting people’s health. The primary concern for health is the potential risk of seizures for individuals with photosensitive epilepsy. Studies have shown that shadow flicker from turbines poses a potential for seizures for 1.7 people in a population of 100,000 photosensitive people if the flicker frequency is greater than 3 Hertz. Current modern utility-scale turbines rotate at frequencies well below this level [2].

4.1 Regulations and shadow flicker standards

CED has identified an internal design goal of limiting non-participating receptors to 30 hours per year of shadow flicker based on realistic conditions that are likely to be experienced, including likely days of cloud cover, seasonal variations, etc. The Minnesota Public Utilities Commission (MNPUC) has recently begun including a 30 hour per year threshold as part of a shadow flicker mitigation permit condition for Large Wind Energy Conversion Systems (LWECS) site permits.

4.2 Shadow flicker model parameters

Shadow flicker was evaluated with the following assumptions outlined in Table 4.

Table 4 Shadow flicker assumptions

Parameter	Value
Year	2021
Maximum Distance (m)	2000
Observer Eye Level (m)	1.5
Interval for Checking Line of Site (m)	5
Ignore shadow flicker when sun is near far horizon	Yes
Time Zone	UTC -6
Account for turbine availabilty	No
Account for turbine orientation	No

Shadow flicker was evaluated under two conditions: (1) not considering any environmental parameters (100 percent sunshine); and (2) considering probabilistic options to ignore shadow flicker when the sun is below 3 degrees near the far horizon and the inclusion of probability of sunshine, which is shown in Figure 4. For both models, turbine orientation was not considered, and turbines were assumed to always be perpendicular to the path of light from the sun to each respective receptor. In addition, wind speed and turbine downtime (availability) were not considered, and turbines area assumed to be always spinning. These assumptions make the model inherently conservative since all these conditions are not possible in reality. The probability of sunshine was derived from long-term hourly data the National Renewable Energy Laboratory's SolarAnywhere database and converted to percentage of sunshine per month [3].

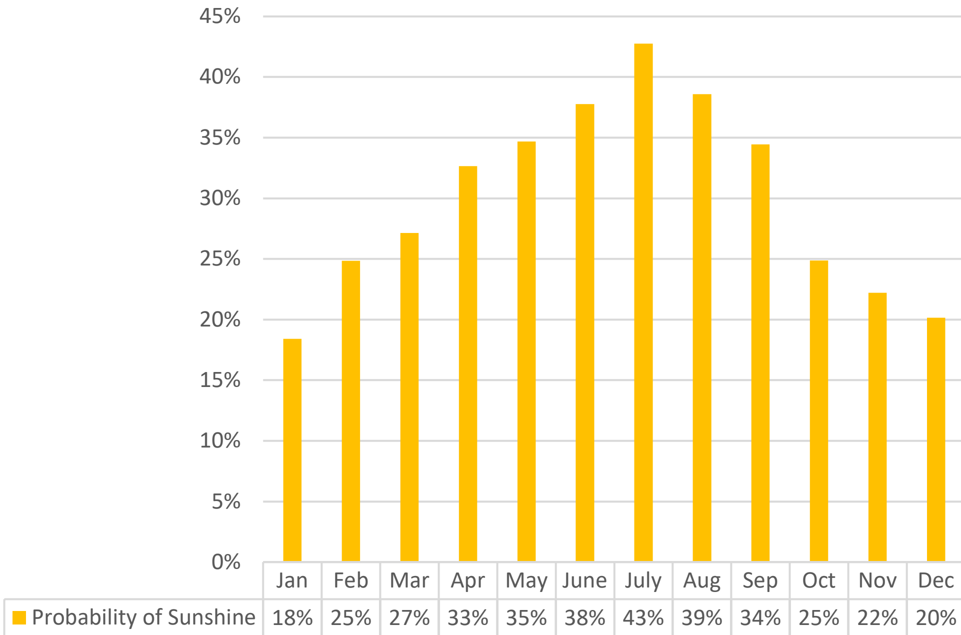

Figure 4 Probability of sunshine per month

4.3 Shadow flicker model results

Shadow flicker was evaluated for all 42 receptors in the Project area for each Project scenario. The shadow flicker model for both scenarios found that 23 receptors were affected by shadow flicker from the Project for both the 100 percent sunshine model and the probability-based model.

The 100 percent sunshine model shows that 6 receptors may experience more than 30 hours per year of shadow flicker for Scenario 1 and Scenario 2. The maximum amount of shadow flicker for the 100 percent model is 65 hours per year for Scenario 1 and 99 hours per year for Scenario 2. When cloud cover is considered in the probability-based model, no receptors experience more than 30 hours of shadow flicker per year. The maximum shadow flicker for the probability-based models is 13 hours per year for Scenario 1 and 22 hours per year for scenario 2, both well below the 30 hour per year standard.

Table 5 presents a summary of the results of the shadow flicker analysis for both Scenarios. Table 6 and Table 7 provide detailed results for Scenario 1 for each receptor for the 100 percent sunshine model and the probability-based model, respectively. Table 8 and Table 9 provide the same detailed results for Scenario 2. The tables include the Project turbines that are causing shadow flicker for each respective receptor (if applicable). Figure 5 and Figure 6 show the visual results of the analysis for each scenario, respectively.

Table 5 Shadow flicker summary results

	Scenario 1		Scenario 2	
	Maximum (100% Sunshine)	Probability Based (Cloud Cover)	Maximum (100% Sunshine)	Probability Based (Cloud Cover)
Receptors w/ shadow flicker	16	16	20	20
> 30 hr/year	5	0	4	0
> 50 hr/year	1	0	2	0
> 100 hr/year	0	0	0	0
Maximum hr/year	65	13	99	22
Maximum 1-day max (min)	57	18	107	30
Maximum days/year	112	109	114	110

Table 6 Scenario 1 shadow flicker results by receptor – 100 percent sunshine

Receptor ID	Status	Occupation Status	Days/year	One-day Maximum (min)	Total/year (min)	Total/year (hr)	Turbines Causing Shadow Flicker (in order from most to least minutes/year) 1	2
R-2	Non-participant	Occupied	0	0	0	0		
R-3	Non-participant	Occupied	0	0	0	0		
R-4	Non-participant	Occupied	0	0	0	0		
R-5	Non-participant	Occupied	0	0	0	0		
R-7	Non-participant	Occupied	0	0	0	0		
R-8	Participant	Occupied	32	18	437	7	T2	
R-9	Participant	Occupied	0	0	0	0		
R-10	Participant	Occupied	0	0	0	0		
R-11	Participant	Occupied	0	0	0	0		
R-12	Non-participant	Occupied	0	0	0	0		
R-13	Non-participant	Occupied	56	19	936	16	T2	
R-229	Non-participant	Occupied	26	17	331	6	T4	
R-230	Non-participant	Occupied	79	26	1506	25	T4	T5
R-231	Non-participant	Occupied	54	25	883	15	T4	T5
R-232	Non-participant	Occupied	0	0	0	0		
R-235	Non-participant	Occupied	0	0	0	0		
R-236	Non-participant	Occupied	0	0	0	0		
R-237	Non-participant	Occupied	0	0	0	0		
R-238	Participant	Occupied	0	0	0	0		
R-239	Participant	Occupied	0	0	0	0		
R-240	Non-participant	Occupied	0	0	0	0		
R-245	Non-participant	Occupied	53	34	1398	23	T5	
R-246	Non-participant	Occupied	40	24	736	12	T2	
R-247	Non-participant	Occupied	112	28	2566	43	T2	T3
R-248	Participant	Occupied	46	35	1240	21	T3	
R-249	Non-participant	Occupied	32	23	589	10	T5	
R-250	Non-participant	Occupied	28	21	472	8	T5	
R-252	Non-participant	Occupied	92	32	1817	30	T6	T7
R-253	Non-participant	Presumed Occupied	0	0	0	0		
R-254	Non-participant	Occupied	0	0	0	0		
R-255	Non-participant	Occupied	0	0	0	0		
R-256	Non-participant	Occupied	0	0	0	0		
R-257	Non-participant	Occupied	0	0	0	0		
R-258	Participant	Occupied	59	48	1978	33	T4	T5
R-259	Non-participant	Occupied	81	57	3908	65	T6	
R-260	Non-participant	Occupied	60	46	2142	36	T6	
R-261	Non-participant	Occupied	0	0	0	0		
R-262	Non-participant	Occupied	0	0	0	0		
R-263	Participant	Occupied	0	0	0	0		
R-264	Non-participant	Occupied	48	35	1318	22	T3	
R-311	Non-participant	Occupied	0	0	0	0		
R-453	Non-participant	Occupied	0	0	0	0		

Table 7 Scenario 1 shadow flicker results by receptor – probability-based

Receptor ID	Status	Occupation Status	Days/year	One-day Maximum (min)	Total/year (min)	Total/year (hr)	Turbines Causing Shadow Flicker (in order from most to least minutes/year) 1	2
R-2	Non-participant	Occupied	0	0	0	0		
R-3	Non-participant	Occupied	0	0	0	0		
R-4	Non-participant	Occupied	0	0	0	0		
R-5	Non-participant	Occupied	0	0	0	0		
R-7	Non-participant	Occupied	0	0	0	0		
R-8	Participant	Occupied	19	6	35	1	T2	
R-9	Participant	Occupied	0	0	0	0		
R-10	Participant	Occupied	0	0	0	0		
R-11	Participant	Occupied	0	0	0	0		
R-12	Non-participant	Occupied	0	0	0	0		
R-13	Non-participant	Occupied	35	6	68	1	T2	
R-229	Non-participant	Occupied	17	4	31	1	T4	
R-230	Non-participant	Occupied	71	10	264	4	T4	T5
R-231	Non-participant	Occupied	45	9	163	3	T4	T5
R-232	Non-participant	Occupied	0	0	0	0		
R-235	Non-participant	Occupied	0	0	0	0		
R-236	Non-participant	Occupied	0	0	0	0		
R-237	Non-participant	Occupied	0	0	0	0		
R-238	Participant	Occupied	0	0	0	0		
R-239	Participant	Occupied	0	0	0	0		
R-240	Non-participant	Occupied	0	0	0	0		
R-245	Non-participant	Occupied	51	11	278	5	T5	
R-246	Non-participant	Occupied	34	9	125	2	T2	
R-247	Non-participant	Occupied	109	13	528	9	T2	T3
R-248	Participant	Occupied	45	17	395	7	T3	
R-249	Non-participant	Occupied	23	8	80	1	T5	
R-250	Non-participant	Occupied	24	7	84	1	T5	
R-252	Non-participant	Occupied	71	12	319	5	T6	T7
R-253	Non-participant	Presumed Occupied	0	0	0	0		
R-254	Non-participant	Occupied	0	0	0	0		
R-255	Non-participant	Occupied	0	0	0	0		
R-256	Non-participant	Occupied	0	0	0	0		
R-257	Non-participant	Occupied	0	0	0	0		
R-258	Participant	Occupied	55	14	329	5	T4	T5
R-259	Non-participant	Occupied	79	18	774	13	T6	
R-260	Non-participant	Occupied	59	17	533	9	T6	
R-261	Non-participant	Occupied	0	0	0	0		
R-262	Non-participant	Occupied	0	0	0	0		
R-263	Participant	Occupied	0	0	0	0		
R-264	Non-participant	Occupied	45	15	275	5	T3	
R-311	Non-participant	Occupied	0	0	0	0		
R-453	Non-participant	Occupied	0	0	0	0		

Table 8 Scenario 2 shadow flicker results by receptor – 100 percent sunshine

Receptor ID	Status	Occupation Status	Days/year	One-day Maximum (min)	Total/year (min)	Total/year (hr)	Turbines Causing Shadow Flicker (in order from most to least minutes/year)		
							1	2	
R-2	Non-participant	Occupied	0	0	0	0			
R-3	Non-participant	Occupied	0	0	0	0			
R-4	Non-participant	Occupied	0	0	0	0			
R-5	Non-participant	Occupied	0	0	0	0			
R-7	Non-participant	Occupied	0	0	0	0			
R-8	Participant	Occupied	24	13	244	4	T-2		
R-9	Participant	Occupied	0	0	0	0			
R-10	Participant	Occupied	0	0	0	0			
R-11	Participant	Occupied	0	0	0	0			
R-12	Non-participant	Occupied	0	0	0	0			
R-13	Non-participant	Occupied	53	15	653	11	T-2		
R-229	Non-participant	Occupied	26	17	331	6	T-4		
R-230	Non-participant	Occupied	71	26	1344	22	T-4	T-5	
R-231	Non-participant	Occupied	49	25	759	13	T-4	T-5	
R-232	Non-participant	Occupied	0	0	0	0			
R-235	Non-participant	Occupied	0	0	0	0			
R-236	Non-participant	Occupied	0	0	0	0			
R-237	Non-participant	Occupied	0	0	0	0			
R-238	Participant	Occupied	28	22	489	8	T-1		
R-239	Participant	Occupied	54	17	782	13	T-1		
R-240	Non-participant	Occupied	0	0	0	0			
R-245	Non-participant	Occupied	55	26	928	15	T-5	T-1	
R-246	Non-participant	Occupied	29	18	417	7	T-2		
R-247	Non-participant	Occupied	103	28	2247	37	T-3	T-2	
R-248	Participant	Occupied	46	35	1240	21	T-3		
R-249	Non-participant	Occupied	114	65	5325	89	T-1	T-5	
R-250	Non-participant	Occupied	21	16	275	5	T-5		
R-252	Non-participant	Occupied	82	25	1375	23	T-6	T-7	
R-253	Non-participant	Presumed Occupied	0	0	0	0			
R-254	Non-participant	Occupied	0	0	0	0			
R-255	Non-participant	Occupied	0	0	0	0			
R-256	Non-participant	Occupied	0	0	0	0			
R-257	Non-participant	Occupied	0	0	0	0			
R-258	Participant	Occupied	98	107	5916	99	T-1	T-5	T-4
R-259	Non-participant	Occupied	76	44	2878	48	T-6		
R-260	Non-participant	Occupied	45	35	1220	20	T-6		
R-261	Non-participant	Occupied	19	12	174	3	T-1		
R-262	Non-participant	Occupied	0	0	0	0			
R-263	Participant	Occupied	19	13	190	3	T-1		
R-264	Non-participant	Occupied	48	35	1318	22	T-3		
R-311	Non-participant	Occupied	0	0	0	0			
R-453	Non-participant	Occupied	0	0	0	0			

Table 9 Scenario 2 shadow flicker results by receptor – probability-based

Receptor ID	Status	Occupation Status	Days/year	One-day Maximum (min)	Total/year (min)	Total/year (hr)	Turbines Causing Shadow Flicker (in order from most to least minutes/year) 1	2	
R-2	Non-participant	Occupied	0	0	0	0			
R-3	Non-participant	Occupied	0	0	0	0			
R-4	Non-participant	Occupied	0	0	0	0			
R-5	Non-participant	Occupied	0	0	0	0			
R-7	Non-participant	Occupied	0	0	0	0			
R-8	Participant	Occupied	14	5	24	0	T-2		
R-9	Participant	Occupied	0	0	0	0			
R-10	Participant	Occupied	0	0	0	0			
R-11	Participant	Occupied	0	0	0	0			
R-12	Non-participant	Occupied	0	0	0	0			
R-13	Non-participant	Occupied	27	4	51	1	T-2		
R-229	Non-participant	Occupied	17	4	31	1	T-4		
R-230	Non-participant	Occupied	66	10	254	4	T-4	T-5	
R-231	Non-participant	Occupied	40	9	146	2	T-4	T-5	
R-232	Non-participant	Occupied	0	0	0	0			
R-235	Non-participant	Occupied	0	0	0	0			
R-236	Non-participant	Occupied	0	0	0	0			
R-237	Non-participant	Occupied	0	0	0	0			
R-238	Participant	Occupied	28	9	124	2	T-1		
R-239	Participant	Occupied	51	11	289	5	T-1		
R-240	Non-participant	Occupied	0	0	0	0			
R-245	Non-participant	Occupied	50	10	209	3	T-5	T-1	
R-246	Non-participant	Occupied	27	8	94	2	T-2		
R-247	Non-participant	Occupied	102	12	467	8	T-3	T-2	
R-248	Participant	Occupied	45	17	395	7	T-3		
R-249	Non-participant	Occupied	110	22	1083	18	T-1	T-5	
R-250	Non-participant	Occupied	19	7	55	1	T-5		
R-252	Non-participant	Occupied	64	12	247	4	T-6	T-7	
R-253	Non-participant	Presumed Occupied	0	0	0	0			
R-254	Non-participant	Occupied	0	0	0	0			
R-255	Non-participant	Occupied	0	0	0	0			
R-256	Non-participant	Occupied	0	0	0	0			
R-257	Non-participant	Occupied	0	0	0	0			
R-258	Participant	Occupied	96	30	1349	22	T-1	T-5	T-4
R-259	Non-participant	Occupied	76	14	596	10	T-6		
R-260	Non-participant	Occupied	44	13	331	6	T-6		
R-261	Non-participant	Occupied	11	3	21	0	T-1		
R-262	Non-participant	Occupied	0	0	0	0			
R-263	Participant	Occupied	10	4	23	0	T-1		
R-264	Non-participant	Occupied	45	15	275	5	T-3		
R-311	Non-participant	Occupied	0	0	0	0			
R-453	Non-participant	Occupied	0	0	0	0			

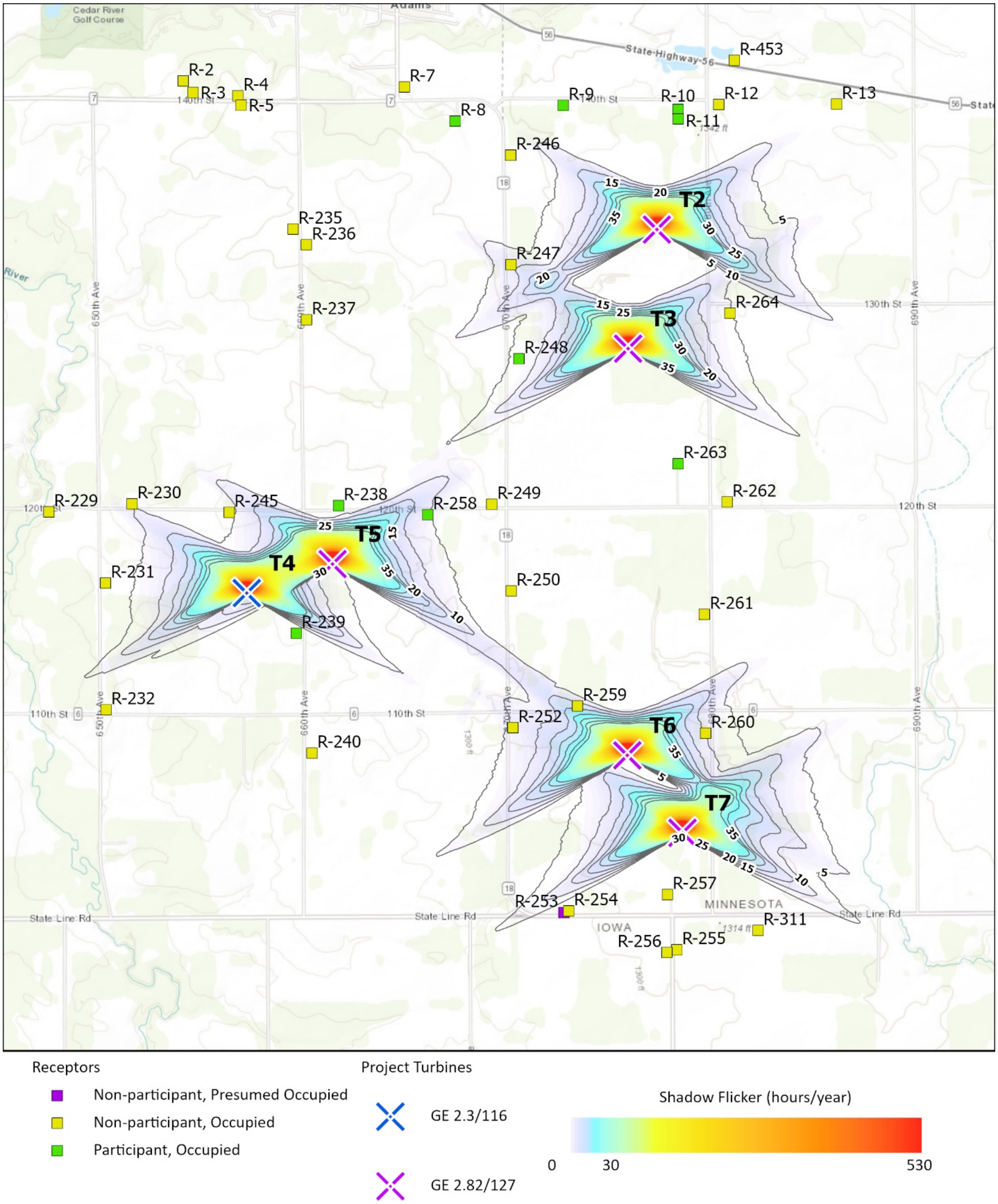

Figure 5 Scenario 1 shadow flicker results

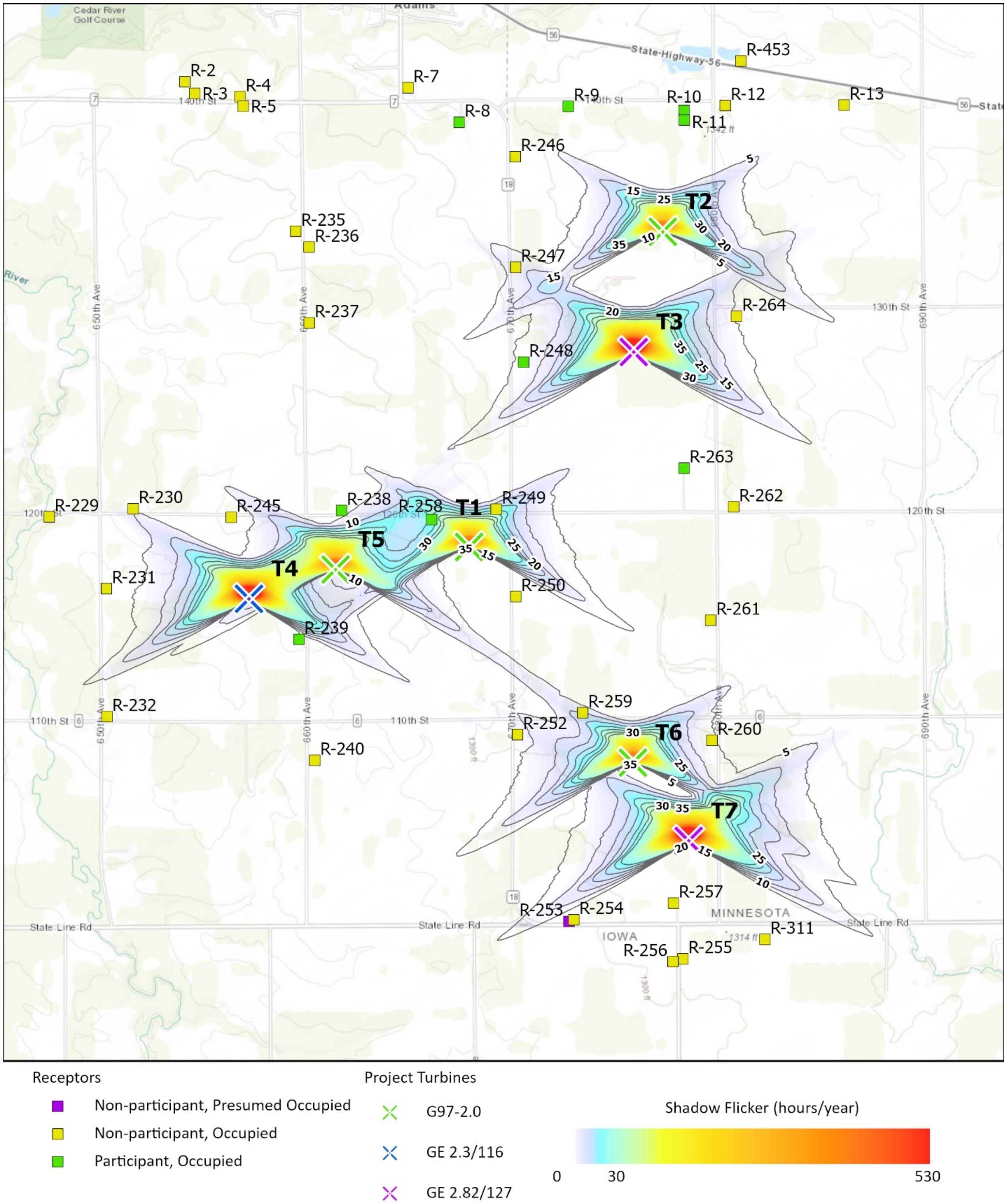

Figure 6 Scenario 2 shadow flicker results

Figure 7 shows the shadow flicker from Scenario 1 based on the day and month of year with respect to time for the receptor that is most impacted by shadow flicker for the 100 percent sunshine case and (R-258, occupied, non-participating residence). The figures show for this specific receptor that shadow flicker would primarily occur in the winter months in the morning, and that the low probability of sunshine during those months eliminates 79 percent of the potential for shadow flicker for the receptor.

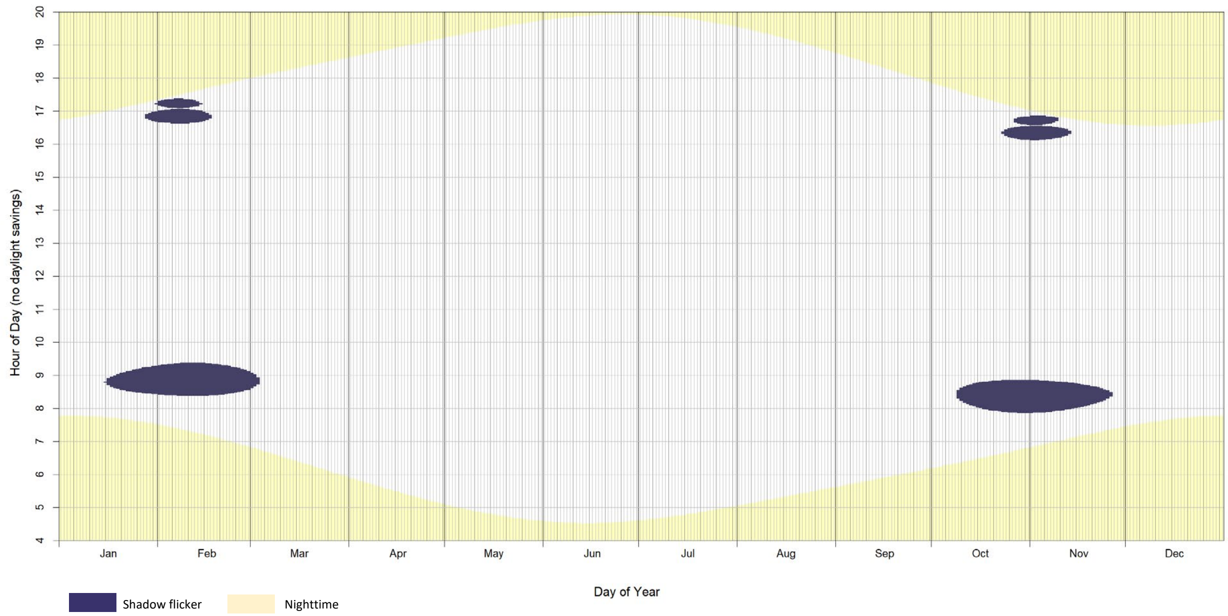

Figure 7 Scenario 1 100 percent sunshine annual-diurnal shadow flicker for receptor R-258

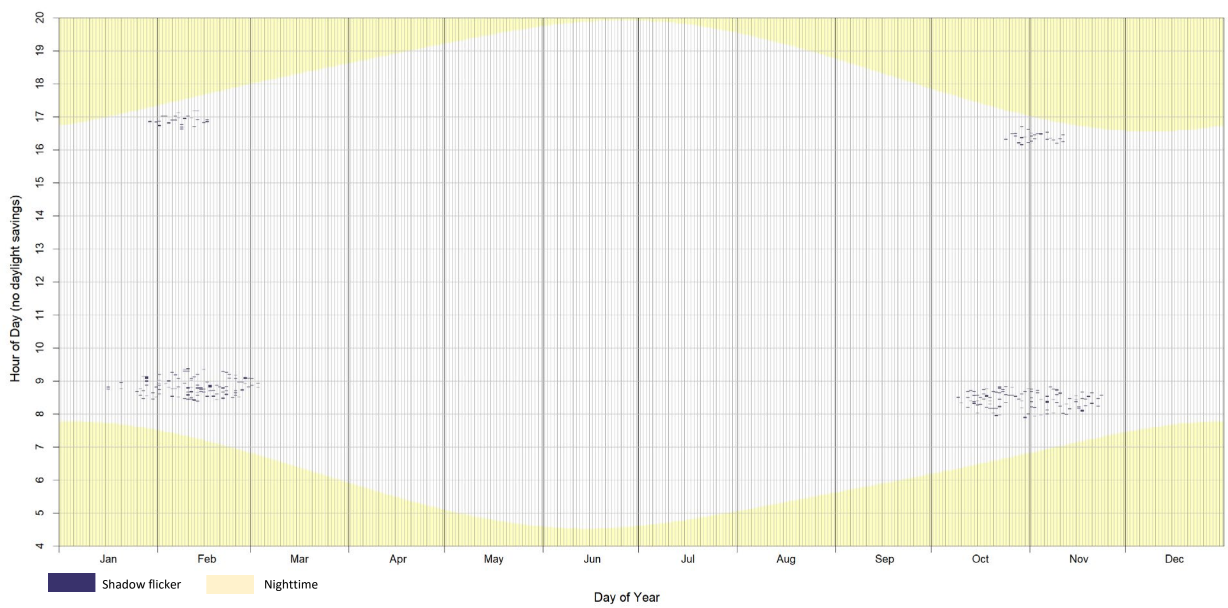

Figure 8 Scenario 1 probability-based annual-diurnal shadow flicker for receptor R-258

In addition, the model does not consider vegetation. As shown in Figure 9, R-258 is completely shielded by trees with respect to the location of T5 and potentially secondary buildings and a tree block the line of site to T1. While the predicted shadow flicker occurs in the late fall and winter months when the deciduous trees will be losing or without foliage, the trees on the property are observed to be a mix of evergreen and deciduous trees.

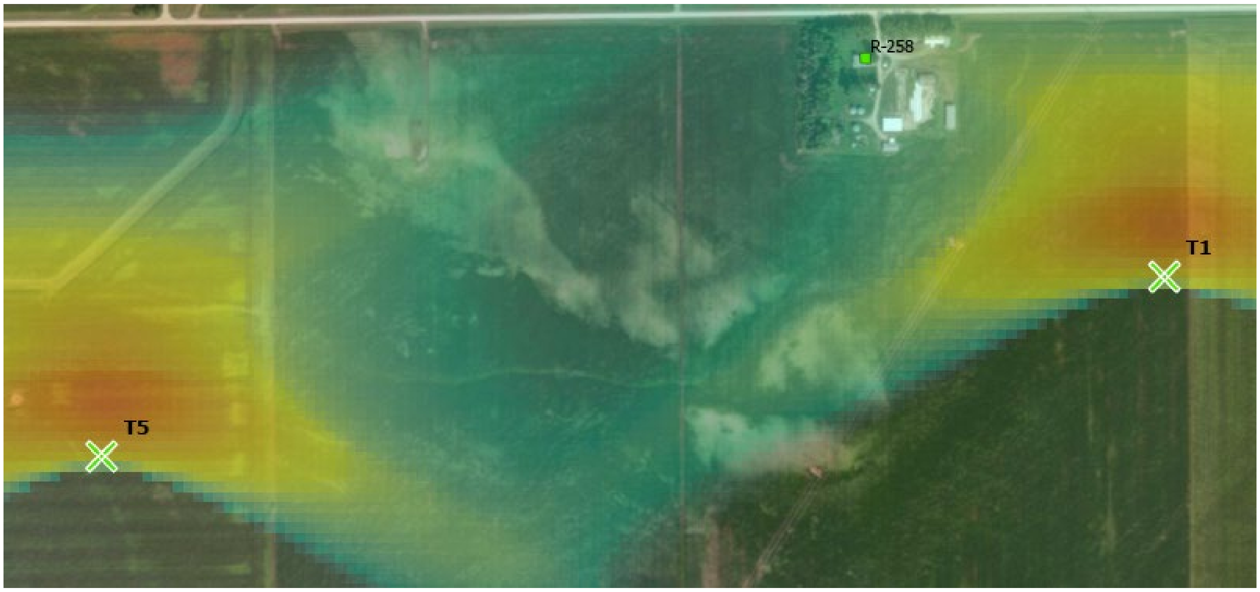

Figure 9 R-258 in relation to T1 and T5

5.0 CONCLUSION

The shadow flicker analyses are intentionally and inherently conservative to show the worst-case potential extent of shadow flicker by the proposed Project scenarios. The results show the potential duration of shadow flicker from the Project on the analyzed receptors to be within the goals defined by CED and the informal standards expected by the MNPUC.

The results of the model do show the potential for shadow flicker that exceeds CED's goal of 30 hours per year, but only under the 100% sunshine model. This is a highly conservative, unrealistic scenario. Shadow flicker effects on receptors typically happen in the morning and evening during the fall and winter months due to the angle of the sun with respect to each turbine and receptor. Based on the normal amount of cloud cover and other mitigating factors such as vegetation, turbine availability and wind speeds, shadow flicker should not significantly impact the receptors around the Project.

6.0 REFERENCES

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